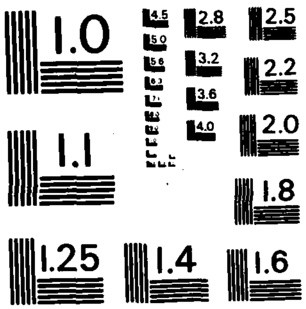
AD-A133 149 1982 INSPECTION OF EXPERIMENTAL MARINE PILING AT PEARL HARBOR HAWAII(U) NAVAL CIVIL ENGINEERING LAB PORT HUENEME CA T B O'NEILL JUL 83 NCEL-TN-1672 1/1

UNCLASSIFIED F/G 11/10 NL

END
DATE
FILMED
10 83
DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

AD-A133 149

(12)

TECHNICAL

TN NO: N-1672

TITLE: 1982 INSPECTION OF EXPERIMENTAL MARINE PILING AT PEARL HARBOR, HAWAII

AUTHOR: Thomas B. O'Neill

DATE: July 1983

SPONSOR: Naval Facilities Engineering Command

PROGRAM NO: YF61.544.091.01.023

NOTE

NAVAL CIVIL ENGINEERING LABORATORY
PORT HUENEME, CALIFORNIA 93043

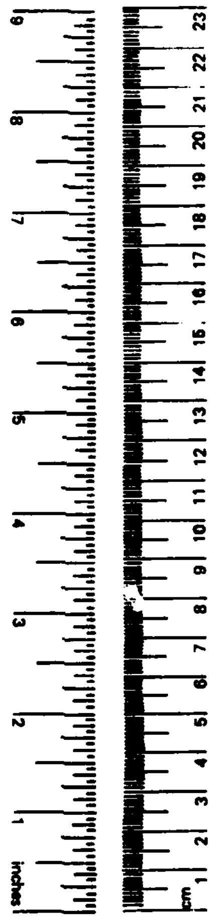
Approved for public release; distribution unlimited.

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

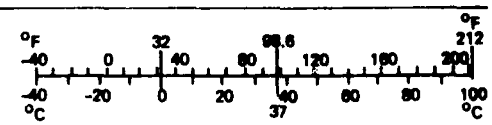
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2,000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1,000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER TN-1672	2. GOVT ACCESSION NO. DN287268	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) 1982 INSPECTION OF EXPERIMENTAL MARINE PILING AT PEARL HARBOR, HAWAII		5. TYPE OF REPORT & PERIOD COVERED Not Final; Jun 1980 – Jun 1982 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Thomas B. O'Neill		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS NAVAL CIVIL ENGINEERING LABORATORY Port Hueneme, CA 93043		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 62761N; YF61.544.091.01.023
11. CONTROLLING OFFICE NAME AND ADDRESS NAVAL FACILITIES ENGINEERING COMMAND Alexandria, VA 22332		12. REPORT DATE July 1983 13. NUMBER OF PAGES 27
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS (of this report) Unclassified 15a. DECLASSIFICATION DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Wood preservation, marine piling, marine borers, chlorinated hydrocarbons

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

> The Navy is considering alternative wood preservatives that are environmentally acceptable. In order to determine the effectiveness of wood preservatives in the marine environment, the Naval Civil Engineering Laboratory (NCEL), in cooperation with industry, installed pilings with test preservatives in Pearl Harbor, Hawaii, in 1963 through 1966 and has observed and evaluated the preservatives. Certain chemicals, such as the chlorinated hydrocarbons, chlordane, and dieldrin, have demonstrated ~~(continued)~~

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

20. Continued

outstanding preservative qualities; the use of such preservatives, however, in the marine environment is subject to EPA restrictions. Basic zinc sulfate is an environmentally acceptable preservative that appears to show promise; its effects on the mechanical properties of wood should be more thoroughly investigated.

Library Card

Naval Civil Engineering Laboratory
1982 INSPECTION OF EXPERIMENTAL MARINE PILING AT PEARL HARBOR, HAWAII, by Thomas B. O'Neill

TN-1672 27 pp illus July 1983 Unclassified

1. Wood preservation 2. Marine piling I. YF61.544.091.01.023

The Navy is considering alternative wood preservatives that are environmentally acceptable. In order to determine the effectiveness of wood preservatives in the marine environment, the Naval Civil Engineering Laboratory (NCEL), in cooperation with industry, installed pilings with test preservatives in Pearl Harbor, Hawaii, in 1963 through 1966 and has observed and evaluated the preservatives. Certain chemicals, such as the chlorinated hydrocarbons, chlordane, and dieldrin, have demonstrated outstanding preservative qualities; the use of such preservatives, however, in the marine environment is subject to EPA restrictions. Basic zinc sulfate is an environmentally acceptable preservative that appears to show promise; its effects on the mechanical properties of wood should be more thoroughly investigated.

CONTENTS

INTRODUCTION

The history of wood preservation is characterized by the continuing search for new protective chemical systems; the present study is part of the Navy's and the Naval Civil Engineering Laboratory's (NCEL's) contribution to this search.

To determine the effectiveness of any wood preservative in the marine environment it is considered mandatory to expose full-size piles impregnated with test agents in seawater with endemic marine borer populations. When piles are placed in tropical waters where marine borer populations and their activity are great, the period of time required to obtain significant results is greatly reduced. NCEL, in cooperation with industry, has installed pilings with test preservatives in Pearl Harbor, Hawaii, and, since the installations, has observed and evaluated the preservatives.

Recently, additional stimuli have increased the concern for the development of new wood preservatives. The continued application of the most commonly used preservatives, creosote and metallic salts, is in jeopardy. In 1971, the Environmental Protection Agency (EPA) declared that creosote is an oil, and the amount of creosote generally released into the surrounding water during the driving of a pile is a reportable violation of the Water Quality Act of 1971. On 18 October 1978, the EPA issued Notices of Rebuttable Presumption against the registration of creosote on the basis that creosote exceeded the risk criteria for various acute and toxic effects on humans. At the same time inorganic arsenicals were placed in the same category; thus, the continued use of ammoniacal copper arsenite (ACA) and chromated copper arsenate (CCA) has been imperiled. The use of arsenic in antifouling paints has been prohibited because of demonstratable adverse effects on the marine environment. Both copper and chromium salts are considered to be suspect. Among the members of the wood preservative industry there is considerable speculation as to whether EPA currently has the desire, funding, and personnel to pursue legislation against the use of creosote and metallic salts. Despite the generally expressed view that creosote and the metallic salts will continue in use because their economic advantages are considered to outweigh their possible hazards, the prudent course for the Navy, with such a large investment in marine timbers and a great need for combat readiness, is to seek alternative methods of preserving wood that are also environmentally acceptable.

Another main concern among those using metallic salts is the embrittlement of wood. Eaton, Drelicharz, and Roe (Ref 1) have demonstrated that, using the American Wood Preservative Association (AWPA) standards of metallic salts (2.5 lb/ft^3) in dual treatment, the mechanical properties of both Douglas fir and southern yellow pine may be reduced by as much as 55%.

Many of the wood preservatives used in this study may be considered as possible alternatives to presently used systems; thus, the lengthy record of exposure in the warm and borer-laden water of Pearl Harbor assumes considerable significance.

PILING TREATMENT AND INSTALLATION

From 1963 to 1966, NCEL, with the cooperation of members of the wood preserving industry and the Cooperative Marine Piling Committee, treated and installed 273 piles at Waipio Peninsula, Pearl Harbor, Hawaii. The Cooperative Piling Committee was an informal group consisting of representatives from the wood treating industry, the Forest Products Laboratory, and the W. F. Clapp Laboratory.

Of the 66 piles driven in 1963, 42 were inadvertently removed in August 1972. Most of the 42 piles were so damaged by borer activity that they broke up during removal, while others were lost or their identification tags were lost. A few of the piles removed were redriven; the 1982 inspection reported herein includes 27 of the piles driven in 1963.

In 1964, 69 piles treated by NCEL and industry were installed. Of these, many were accidentally removed as cited above; all but three were structurally sound and were redriven in May 1973.

In 1965, 78 NCEL-treated piles were installed. Many of these were removed in 1972, and 48 were subsequently redriven in May 1973.

The last group, consisting of 60 piles, was driven in 1966. The piles had been treated by private companies or by NCEL, or initially treated by private companies and subsequently treated by NCEL. None of this group was accidentally removed as described above.

A general summary of treatment given to all piles is found in Table 1, and more specific treatments are cited in the various tables recording observations.

PILING INSPECTION

From the first inspection in 1967 through 1974 the piles were visually inspected from the surface of the water. Because of the difficulty encountered in trying to observe the damage of submerged surfaces, a decision was made to have a diver examine the piles. In 1975, NCEL contracted with Mr. Al Hanson, a diver with more than 30 years of experience inspecting piling at the Port of Los Angeles. During this period, Mrs. Hanson, who is both a licensed diver and diver tender, served as a tender and recorder. Similar contracts were given to the Hansons for the 1977, 1978, and 1982 inspections. During the most recent inspection certain piles were evaluated by ultrasonic methods by J. Agi and Associates for a work unit in the Specialized Inspection Systems project at NCEL; these results were compared with the visual observations. Where significant differences in evaluation by the two different techniques existed, pilings were removed and will be cut into cross sections for a possible explanation of observational discrepancies. The Hansons report the percentage loss of a cross-sectional area of a pile; this is expressed in a single number. The nature of the loss and the genus causing destruction are frequently cited, as is the presence of splits, checks, and other damage. Agi and Associates report the percentage of the

piling considered to be sound; often the results are stated within a range, (e.g., 10 to 25%). In comparing observations, the Agi results have been converted to express percentage loss so as to facilitate comparisons.

FINDINGS AND CONCLUSIONS

The reader is referred to References 2 to 18 for reports on the inspections prior to 1982.

The principal borers recorded from Pearl Harbor are the crustaceans, Limnoria tripunctata and Sphaeroma terebransi; and the molluscans, Martesia striata, Teredo spp, and Bankia spp.

The Hanson and Agi evaluations are summarized in Tables 2 to 9. A comparison of findings during the inspections of 1976 and 1978 is also given in these tables. Summaries citing the number of piles showing a percent category of damage are also included. The categories used are as follows: (1) damage less than 5%, (2) damage between 5 and 15%, (3) damage between 15 and 50% and (4) damage greater than 50%. The degree of damage determines the method of repair. Piling is wrapped when damage is between 5 and 15%. When the damage is between 15 and 50% of the cross-sectional area the piling is repaired with grout or concrete. When damage exceeds 50% the damaged area is replaced with wood or concrete.

1963 Series

In this series all piling was treated with creosote and, in addition, most were treated with another preservative.

Treatment of piles with ammoniacal copper arsenite (ACA) followed by creosote appears to offer considerable protection against all borers, though it is believed that this protection is due to the high salt concentration (6.9 lb/ft^3 rather than the standard 2.5 lb/ft^3). When a standard amount of chromated copper arsenate (CCA) is used in combination with a below-standard amount of creosote (8.4 lb/ft^3), in lieu of the standard 25 lb/ft^3, the results are significantly poorer, with damage resulting from Limnoria, Teredo, and Martesia. When the standard amounts of both CCA and creosote are used the results are nondefinitive. Widely varying results in only three pilings offers no statistical reliability. One of the pilings had but 2% damage due to Limnoria after 19 years, a second had 5% damage due to Martesia, and the third piling was completely destroyed by Limnoria. This author believes that a "weakest link" concept should be applicable: if all pilings are basically the same, as has been their treatment with preservatives, and only one has been destroyed by borers, then the others are equally susceptible but happened to be placed in a location where borer populations are minimal.

Single treatment using 70-30 creosote-coal tar appears to offer slightly better protection for Douglas fir than for southern yellow pine, although the small number of pilings observed offers no firm statistical basis for definitive conclusions.

Dual treatment of 70-30 creosote-coal tar followed by either 1 or 5% phenylmercuric oleate (PMO) gave promising results except for two piles: one of Douglas fir with 1% PMO had 50% damage due to Limnoria in 1982; and another, of southern yellow pine with 5% PMO, was rated as having 90% damage, again due to Limnoria attack, in 1982.

The single pile treated with 70-30 creosote-coal tar and covered with cupro-nickel sheeting is, after 19 years of immersion, in excellent condition.

The damage to the five control piles (Douglas fir) impregnated with NCEL creosote only (17.2 lb/ft^3) was 5, 5, 5, 7, and 7%, respectively.

1964 Series

All of the piles in this series were treated with creosote and, with the exception of controls, other preservatives.

Chlordane, both in 2.5 and 5% additives to creosote, gave excellent results against all borers with a maximum damage of 4%. All of the damage was due to Limnoria. A 1.25% chlordane additive gave good results, with damage from Limnoria varying from 2 to 15%. Copper naphthenate in high concentrations (30%) yielded good results, even when added to less-than-standard amounts of creosote (8.3 lb/ft^3). In lower concentrations of 7.5 and 15%, copper naphthenate gave poor results, with damage resulting from both Martesia and Limnoria activity. No significant preservative power was imparted by the use of 1% tributyltin oxide (TBTO) as the sole additive or with copper naphthenate, damage from Limnoria activity being most significant. A combination of 1% dieldrin and 1% TBTO was very effective, though the dieldrin is believed to be chiefly responsible for the effectiveness. Where 1% TBTO was the sole additive, piling damage was 92 to 100%.

1965 Series

In this series the solvent for preservatives was xylene, not creosote. Copper oxinate appears to give good protection against all borers only when the amount of retention is 0.50 lb/ft^3 or more. In lesser amounts copper oxinate appears to offer only fair protection, either alone or when used with other agents, such as tributyltin oxide, Victoria green base, and creosote. Limnoria and to a lesser extent Martesia appear to be most prevalent. In this series 5% chlordane yielded encouraging results when used with TBTO, with damage varying from 2 to 6% in 12 piles. This damage was caused by both Limnoria and Martesia.

1966 Series

This series has the greatest number of variations as to piling sources as well as preservatives used. Four groups were treated with one preservative, and six were treated with two anti-borer agents.

Chromated copper arsenate (CCA) gave poor results as did dual treatment with copper sulfate and TBTO. Limnoria caused the greatest amount of damage. Martesia was found in approximately one-half the piles, and Teredo was found in only a few. Chromated copper arsenate (CCA) gave good results when used with TBTO. Basic zinc sulfate also yielded good results when used alone or in combination with TBTO, showing a maximum damage of 4%.

Visual Evaluation Compared With Ultrasonic Evaluation

In a comparison of visual inspection by a diver with ultrasonic testing of 52 piles, findings were comparable in 30 of the piles. This conclusion may be misleading because the ultrasonic results are frequently expressed in a range of two figures, a low and a high. A piling rated visually by a diver as having a 3% loss was evaluated by the ultrasonic device as having a 0 to 25% loss. Eleven of the piles evaluated by both methods had a significant variation. A visually determined 2% loss of cross-sectional area was, in several piles, rated by the ultrasonic technique as having a 10 to 25% loss.

DISCUSSION AND RECOMMENDATIONS

The existence of a relatively large number of pilings experimentally treated with different preservatives and placed, 17 to 20 years ago, in a tropical marine environment with heavy populations of different species of marine borers is of great value. The experimental pilings at Pearl Harbor are, for the above reasons, unique and thus should be maintained and evaluated at periodic intervals, and the results should be used to program future research.

Certain treatments have demonstrated outstanding preservative qualities (e.g., chlorinated hydrocarbons, such as chlordane and dieldrin). The EPA has banned their use in the marine environment; thus, research should be based on alternative forms of these materials. Analogues of the chlorinated hydrocarbons might be prepared so that a moiety, toxic to marine borers and yet environmentally acceptable, could be released. A second approach would be to investigate the mechanism of toxicity to borers and duplicate the reaction using alternative, environmentally safe agents.

The protection of piling with cupro-nickel sheathing, once common in the past, has been discontinued because of the expense of the material and difficulty in its application. After 20 years in Pearl Harbor, it is rated as excellent. A study of its cost effectiveness is in order, as is the possible use of thinner sheets. When cupro-nickel was extensively used, it was primarily considered as a mechanical barrier to borers. Today the role of sheathing in the exclusion of oxygen for borer activity is considered preeminent. Perhaps thinner and thus less expensive and more manageable sheets should be considered.

Basic zinc sulfate appears to be a promising wood preservative against all borers in Pearl Harbor. It is environmentally safe and thus should be more extensively tested. At the present moment no knowledge of possible embrittlement resulting from zinc sulfate treatment exists; therefore, this characteristic must be investigated.

Certain compounds traditionally believed to be promising as preservatives have, in the present study, been clearly unacceptable and yet they continue to be tested. Copper naphthenate and tributyltin oxide are examples of such compounds.

REFERENCES

1. Civil Engineering Laboratory. Technical Note 1535: Mechanical properties of preservative treated marine piles: Results of limited full scale testing, by M. L. Eaton, J. A. Drelicharz, and T. Roe, Jr. Port Hueneme, Calif., Nov 1978.

2. Naval Civil Engineering Laboratory. Technical Note N-473: Cooperative marine piling investigation, Phase 1 - Pile driving at Coco Solo, Canal Zone, by H. Hochman. Port Hueneme, Calif., Apr 1963 (AD 405914)

3. ____________. Technical Note N-503: Cooperative marine piling investigation, Phase 2 - Pile driving at Pearl Harbor, Hawaii, by H. Hochman. Port Hueneme, Calif., Jul 1963. (AD 417175)

4. ____________. Technical Note N-672: Experimental wood piling treatments FY-64, by T. Roe, Jr., and H. Hochman. Port Hueneme, Calif., Dec 1964. (AD 456491)

5. ____________. Technical Note N-677: Driving of piles treated with creosote containing additives, by H. Hochman. Port Hueneme, Calif., Dec 1964. (AD 458071)

6. ____________. Technical Note N-736: Experimental wood piling treatments FY-65, by T. Roe, Jr., and H. Hochman. Port Hueneme, Calif., Aug 1965. (AD 468487)

7. ____________. Technical Note N-898: Experimental wood preservative systems. Treatment; FY 66, Driving, FY 67, by H. Hochman and T. Roe, Jr. Port Hueneme, Calif., Jun 1967. (AD 816825L)

8. ____________. Technical Note N-879: Cooperative marine piling investigation - Phase III - Inspection after four years exposure, by H. Hochman. Port Hueneme, Calif., Mar 1967. (AD 811337L)

9. ____________. Technical Note N-957: Cooperative marine piling investigation - Phase IIIA - Inspection after five years exposure, by H. Hochman. Port Hueneme, Calif., Apr 1968. (AD 831178L)

10. ____________. Technical Note N-1048: 1969 inspection of experimental marine piling, by H. Hochman. Port Hueneme, Calif., Sep 1969. (AD 859356)

11. ____________. Technical Note N-1116: 1970 inspection of experimental marine piling, by H. Hochman. Port Hueneme, Calif., Jul 1970. (AD 873228L)

12. ____________. Technical Report R-757: Evaluation of pile preservatives at Coco Solo and Pearl Harbor, by H. Hochman. Port Hueneme, Calif., Feb 1972. (AD 740753)

13. ____________. Technical Note N-1253: 1972 inspection of experimental marine piling, by H. Hochman. Port Hueneme, Calif., Dec 1972. (AD 753194)

14. ___________. Technical Note N-1298: 1973 inspection of experimental marine piling, by H. Hochman. Port Hueneme, Calif., Jul 1973 (AD 767636)

15. Naval Civil Engineering Laboratory. Contract Report CR 74.009: *The inspection and evaluation of experimentally treated wood piling*, by H. Hochman. Oxnard, Calif., Jun 1974. (Contract N68305-74-C-0010)

16. ___________. Technical Note N-1418: 1975 inspection of experimental marine piling, by T. Roe, Jr. Port Hueneme, Calif., Dec 1975. (AD A021843)

17. ___________. Technical Note N-1466: 1976 inspection of experimental marine piling, by T. Roe, Jr. Port Hueneme, Calif., Dec 1976. (AD A035800)

18. ___________. Technical Note N-1538: 1978 inspection of experimental marine piling, by T. Roe, Jr. Port Hueneme, Calif., Dec 1978. (AD _______)

Table 1. Experimentally Treated Piles Driven at Pearl Harbor

Year Driven	Source of Piles[a]	Number of Different Treatments	Number of Piles Per Treatment	Total Piles	Summary of Treatments
1963	Coop	10	6	60	Inorganic salt followed by creosote (double treatment); 70-30 creosote-coal tar solution; phenylmercuric oleate dissolved in 70-30 cresote-coal tar solution; 70-30 creosote-coal tar solution followed by sheathing with 90:10 cupro-nickel alloy
1963	NCEL	1	6	6	Type III creosote
1964	NCEL	9	6	54	Creosote solutions of specific organic compounds and/or metal organic compounds
1964	OWPC	1	4	15	Creosote solutions of specific organic and metal organic compounds
1965	NCEL	13	6	78	Solutions of specific organic and metal organic compounds in xylene or creosote
1966	NCEL	2	6	12	Double treatment: copper sulfate followed by tributyltin oxide
1966	BCCWP	1	6	6	Chromated copper arsenate (Type B)
1966	AZLS	3	6	6	Basic zinc sulfate
1966	AZLS	3	6	18	Ammoniacal copper arsenite; 70-30 creosote-coal tar solution; double treatment: ammoniacal copper arsenite followed by 70-30 creosote-coal tar solution
1966	AZLS/ NCEL	1	6	6	Double treatment: basic zinc sulfate followed by tributyltin oxide
1966	BCCWP/ NCEL	1	6	6	Double treatment: chromated copper arsenate (Type B) followed by tri-butyltin oxide
1966	JHB/ NCEL	1	6	6	Double treatment: ammoniacal copper arsenite followed by tributyltin oxide

[a]AZLS = American Zinc, Lead, and Smelting Co.
BCCWP = British Columbia Clean Wood Preservers, Ltd.
Coop = Cooperative Marine Piling Committee
JHB = J.H. Baxter and Co.
NCEL = Naval Civil Engineering Laboratory
OWPC = Osmose Wood Preserving Company of America

Table 2. Results of Three Yearly Inspections of Piles Installed in 1963

Treatment	Retention (lb/ft^3)				Percent Loss of Cross-Sectional Area for--														
	Cooperative Assay		NCEL Assay		Piling No. 1			Piling No. 2			Piling No. 3			Piling No. 4			Piling No. 5		
	Oil	Salt	Oil	Salt	1976	1978	1982	1976	1978	1982	1976	1978	1982	1976	1978	1982	1976	1978	1982
Ammoniacal copper arsenate followed by creosote in Douglas fir	16.2	6.9	9.7	--	0	0	2	0	1	3[a]	0	0	4[b]	--	--	--	--	--	--
Chromated copper arsenate followed by creosote in Douglas fir	8.4	2.7	2.7	--	4	12	88[c,d]	7	55	95[c,d,e]	2	2	10[f]	--	--	--	--	--	--
Chromated copper arsenate followed by creosote in southern yellow pine	23.2	2.7	17.3	--	0	100[g]	100[g]	0	1	2[f]	0	0	5[a]	--	--	--	--	--	--
70-30 creosote-coal tar solution in Douglas fir	15.3	--	11.1	--	0	1	3[f]	0	7	7[c]	0	0	4[f]	--	--	--	--	--	--
70-30 creosote-coal tar solution in southern yellow pine	17.7	--	13.5	--	6	15	40[c,d]	2	10	20[c,h]	--	--	--	--	--	--	--	--	--
70-30 creosote-coal tar solution containing 1% phenylmercuric oleate[1] in Douglas fir	20.7	--	18.5	--	5	13	50[c]	0	0	2[c]	1	1	5[c]	--	--	--	--	--	--
70-30 creosote-coal tar solution containing 1% phenylmercuric oleate[1] in southern yellow pine	24.1	--	18.5	--	0	3	3[c]	--	--	--	--	--	--	--	--	--	--	--	--

continued

Table 2. Continued

Treatment	Retention (lb/ft³)				Percent Loss of Cross-Sectional Area for--														
	Coopera-tive Assay		NCEL Assay		Piling No. 1			Piling No. 2			Piling No. 3			Piling No. 4			Piling No. 5		
	Oil	Salt	Oil	Salt	1976	1978	1982	1976	1978	1982	1976	1978	1982	1976	1978	1982	1976	1978	1982
70-30 creosote-coal tar solution containing 5% phenylmercuric oleate[i] in Douglas fir	13.0	--	10.0	--	0	2	7[d,f]	--	--	--	--	--	--	--	--	--	--	--	--
70-30 creosote-coal tar solution containing 5% phenylmercuric oleate[i] in southern yellow pine	27.5	--	22.1	--	7	12	90[c]	0	3	5[c]	--	--	--	--	--	--	--	--	--
70-30 creosote-coal tar solution in southern yellow pine followed by sheathing with cupro-nickel alloy	--	--	--	0	0	0	--	--	--	--	--	--	--	--	--	--	--	--	--
NCEL creosote in Douglas fir	--	--	17.2	--	3	4	5[c,d]	0	2	5[c]	3	5	5[c]	0	3	7[c]	3	4	7[c,d]

[a]Dead *Martesia*.
[b]Few *Limnoria*.
[c]*Limnoria*.
[d]*Martesia*.
[e]*Teredo*.
[f]Slight *Limnoria*.
[g]Pile hit and broken.
[h]Slight *Martesia*.
[i]Nominal percentages. Analyses of core borings showed that considerably less than the nominal percentage penetrated into the wood. No individual retention figures were reported.

Table 3. Summary of Three Yearly Inspections of Piles Installed in 1963, Pulled in 1972, and Redriven in 1973

Treatment	No. of Piles	Number of Piles According to Damage Categories Attacked in--								
		1976		1978			1982			
		<5%	5-15%	<5%	5-15%	15-50%	<5%	5-15%	15-50%	>50%
Ammoniacal copper arsenite followed by creosote in Douglas fir	3	3/3[a]	--	3/3	--	--	3/3	--	--	--
Chromated copper arsenate followed by creosote in Douglas fir	3	2/3	1/3	1/3	1/3	1/3	--	1/3	--	2/3
Chromated copper arsenate followed by creosote in southern yellow pine	3	3/3	--	2/3	--	1/3	1/3	1/3	--	1/3
70-30 creosote-coal tar solution in Douglas fir	3	2/3	--	2/3	1/3	--	2/3	1/3	--	--
70-30 creosote-coal tar solution in southern yellow pine	2	1/2	1/2	--	2/2	--	--	--	2/2	--
70-30 creosote-coal tar solution containing 1% phenylmercuric oleate[b] in Douglas fir	3	2/3	1/3	2/3	1/3	--	1/3	1/3	1/3	--
70-30 creosote-coal tar solution containing 1% phenylmercuric oleate[b] in southern yellow pine	1	1/1	--	1/1	--	--	1/1	--	--	--

continued

Table 3. Continued

Treatment	No. of Piles	Number of Piles According to Damage Categories Attacked in--								
		1976		1978			1982			
		<5%	5-15%	<5%	5-15%	15-50%	<5%	5-15%	15-50%	>50%
70-30 creosote-coal tar solution containing 5%[b] phenylmercuric oleate in Douglas fir	1	1/1	--	1/1	--	--	--	1/1	--	--
70-30 creosote-coal tar solution containing 5%[b] phenlymercuric oleate in southern yellow pine	2	1/2	1/2	1/2	1/2	--	--	1/2	--	1/2
70-30 creosote-coal tar solution in southern yellow pine followed by sheathing with cupro-nickel alloy	1	1/1	--	1/1	--	--	1/1	--	--	--
NCEL creosote in Douglas fir	5	5/5	--	4/5	1/5	--	--	5/5	--	--

[a]The fraction is interpreted as follows. The denominator denotes the number of piles inspected, and the numerator designates the number of piles in a specific category. Thus, for example, in the 1982 inspection of the three Douglas fir piles treated with chromated copper arsenate and creosote, two had greater than 50% damage and one had 5 to 15% damage.

[b]Nominal percentages. Analyses of core borings showed that considerably less than the nominal percentage penetrated into the wood.

Table 4. Results of Three Yearly Inspections o

Creosote Additive	Creosote Retention (lb/ft^3)	Additive Retention (lb/ft^3)	Percent Loss of Cross-S												
			Piling No. 1				Piling No. 2				Piling No. 3				
			1976	1978	1982	1982[a]	1976	1978	1982	1982[a]	1976	1978	1982	1982[a]	197
None	32.9	0.00	2	3	3[b]	0-25	2	2	3[b]	0	0	1-2	3	0	3
None	18.6	0.00	26	33	94[b,d]	100	26	26	94[b]	100	30	67	100[b]	100	16
1.25% chlordane	26.3	0.3	0	1	2[b]	10-25	0	0	2[b]	10	0	0	4[b]	--	1
2.5% chlordane	28.5	0.7	0	1	3[b]	0	0	0	2[b]	--	2	3	4[b]	0-25	3
5% chlordane	28.6	1.4	0	0	2[b]	0-25	0	0	3[b]	10	0	1	2[b]	--	0
7.5% copper naphthenate	10.9	0.09[f]	65	97	100[b]	100	0	0	2[b]	10-25	35	73	100[b]	--	2
15% copper naphthenate	9.4	0.15[f]	2	8	28[b,e]	100	0	0	3[b]	--	32	42	92[b,e]	100	0
30% copper naphthenate	8.3	0.27[f]	0	2	2[b]	--	0	5	7[b]	--	1	3	4[b,e]	0-25	2
7% copper naphthenate 0.5% tributyltin oxide	8.6	0.07[f] 0.08	0	1	3[b]	0-25	4	8	38[b]	--	0	1	2[b]	--	2
14% copper naphthenate 1% tributyltin oxide	14.8	0.23[f] 0.15	8	18	92[b,e]	100	3	8	22[b]	25-50	0	2	3[b]	0	7
1% tributyltin oxide	13.9	0.14	4	18	92[b]	100	40	63	100[b]	100	13	28	100[b]	100	30
1% tributyltin oxide 1% dieldrin	17.4	0.18 0.18	0	2	2[b]	10	0	0	2[b]	--	0	0	0	--	0

[a]Agi and Associates.
[b]*Limnoria*.
[c]Few *Martesia*.
[d]Some *Martesia*.
[e]*Martesia*.
[f]As metallic copper.
[g]*Teredo*.

of Three Yearly Inspections of Piles Installed in 1964

Percent Loss of Cross-Sectional Area for--																
	Piling No. 3				Piling No. 4				Piling No. 5				Piling No. 6			
1982[a]	1976	1978	1982	1982[a]	1976	1978	1982	1982[a]	1976	1978	1982	1982[a]	1976	1978	1982	1982[a]
0	0	1-2	3	0	3	5	20[b]	0-25	3	5	9[b,c]	10	3	3	3[b]	10
100	30	67	100[b]	100	16	30	100[b,e]	100	--	--	--	--	--	--	--	--
10	0	0	4[b]	--	1	2	15[b]	25-20	0	1	3[b]	--	3	4	10[b]	0-25
--	2	3	4[b]	0-25	3	3	4[b]	--	0	0	2[b]	--	0	0-1	2[b]	10-25
10	0	1	2[b]	--	0	1	1[b]	0-25	0	0	3	0	0	0	0	0
10-25	35	73	100[b]	--	2	3	5[b]	--	3	4	7[b]	--	2	4	5[b]	--
--	32	42	92[b,e]	100	0	3	4[b,e]	10	15	18	55[b]	100	18	92	100[b,e,g]	100
--	1	3	4[b,e]	0-25	2	7	11[b,e]	25-50	2	5	9	25-50	0	1	2[b]	0-25
--	0	1	2[b]	--	2	7	42[b]	100	30	77	99[b,c]	--	7	28	100[b,c]	--
25-50	0	2	3[b]	0	7	28	93[b]	--	48	94	98[b]	100	8	69	100[b,c]	100
100	13	28	100[b]	100	30	94	100[b]	100	29	65	100[b,e,g]	100	--	--	--	--
--	0	0	0	--	0	0	0	0-25	0	0	2[b]	--	0	0	2	0-25

2

Table 5. Summary of Three Yearly Inspections of Piles Installed in 1964[a]

Creosote Additive	Creosote Retention (lb/ft^3)	Additive Retention (lb/ft^3)	No. of Piles	Number of Piles According to Damage Category Reported Attacked in--											
				1976				1978				1982			
				<5%	5-15%	15-50%	>50%	<5%	5-15%	15-50%	>50%	<5%	5-15%	15-50%	>50%
None	32.9	0	6	6/6	--	--	--	4/6	2/6	--	--	4/6	1/6	1/6	--
None	18.6	0	4	--	--	4/4	--	--	--	3/4	1/4	--	--	--	4/4
1.25% chlordane	26.3	0.3	6	6/6	--	--	--	6/6	--	--	--	4/6	2/6	--	--
2.5% chlordane	28.5	0.7	6	6/6	--	--	--	6/6	--	--	--	6/6	--	--	--
5% chlordane	28.6	1.4	6	6/6	--	--	--	6/6	--	--	--	6/6	--	--	--
7.5% copper naphthenate	10.9	0.09[b]	6	4/6	--	1/6	1/6	4/6	--	--	2/6	1/6	3/6	--	2/6
15% copper naphthenate	9.4	0.15[b]	6	3/6	1/6	2/6	--	2/6	1/6	2/6	1/5	2/6	--	1/6	3/6
30% copper naphthenate	8.3	0.27[b]	6	6/6	--	--	--	3/6	3/6	--	--	3/6	3/6	--	--
7% copper naphthenate 0.5% tributyltin oxide	8.6	0.07[b] 0.08	6	4/6	1/6	1/6	--	2/6	1/6	2/6	1/6	2/6	--	2/6	2/6
14% copper naphthenate 1% tributyltin oxide	14.8	0.23[b] 0.15	6	2/6	3/6	1/6	--	1/6	1/6	2/6	2/6	1/6	--	1/6	4/6
1% tributyltin oxide	13.9	0.14	5	1/5	3/5	2/5	--	--	--	2/5	3/5	--	--	--	5/5
1% tributyltin oxide 1% dieldrin	17.4	0.18 0.18	6	6/6	--	--	--	6/6	--	--	--	6/6	--	--	--

[a]These piles were accidentally pulled in August 1972 and redriven in May 1973.

[b]As metallic copper.

Table 6. Results of Three Yearly Inspections of NCEL-Treated Piles Ins

Treatment (Solutions in Xylene)	Retention (lb/ft^3)	Percent Loss of Cross-Sectional Ar												
		Piling No. 1				Piling No. 2				Piling No. 3			Piling No	
		1976	1978	1982[b]	1982	1976	1978	1982	1982[b]	1976	1978	1982	1976	1978
4% copper oxinate	0.87[c]	0	4	8[d]	--	0	1	2[d]	--	1	1	3[d]	1	5
2% copper oxinate	0.49[c]	0	2	2[d,e]	--	2	4	6[d]	--	10	20	40[d,e]	0	0
2% copper oxinate 2% tributyltin oxide	0.25[c] 0.25	3	20	70[d,e,f]	100	4	12	85[d,e]	--	2	5	20[d,e]	0	4
3% copper oxinate 1% Victoria green base	0.69[c] 0.26	0	3	25[d,e]	--	2	5	8[d,e]	--	0	--	--	0	2
5% chlordane 1% tributyltin oxide	1.3 0.27	0	2	3[d]	--	0	0	2[h]	--	0	1	4[e]	0	3
5% chlordane 2% tributyltin oxide	1.5 0.62	0	0	2[d]	--	1	1	3[e]	--	0	0	2[d]	0	0
1.5% copper oxinate 0.5% Victoria green base 30% creosote	0.27[c] 0.09 9.2	4	6	8[d]	50	7	12	70[d,e,f]	100	5	5	90[d,e]	3	5
0.75% copper oxinate 0.25% Victoria green base 75% creosote	0.25[c] 0.08 24.7	0	0	3[d]	--	2	6	85[d]	--	0	3	8[d]	0	0

[a]These were accidentally removed in August 1972 and redriven in May 1973.

[b]Agi and Associates.

[c]As metallic copper.

[d]*Limnoria*.

[e]*Martesia*.

[f]*Teredo*.

[g]Pile missing.

[h]Few *Limnoria*.

ree Yearly Inspections of NCEL-Treated Piles Installed in 1965[a]

Percent Loss of Cross-Sectional Area for--																	
Piling No. 2				Piling No. 3			Piling No. 4				Piling No. 5				Piling No. 6		
1976	1978	1982	1982[b]	1976	1978	1982	1976	1978	1982[b]	1982	1976	1978	1982	1982[b]	1976	1978	1982
0	1	2[d]	--	1	1	3[d]	1	5	12[d,e]	--	1	3	6[d]	--	0	0	3[d]
2	4	6[d]	--	10	20	40[d,e]	0	0	5[d,e]	--	3	4	7[d]	--	0	2	7[d]
4	12	85[d,e]	--	2	5	20[d,e]	0	4	18[d,e]	--	0	7[d]	100[g]	--	3	6	15[d]
2	5	8[d,e]	--	0	--	--	0	2	3[d,e]	--	0	1	8[d]	--	3	6	9[d,e]
0	0	2[h]	--	0	1	4[e]	0	3	6[d]	--	0	0	5[d]	10	0	0	2[d]
1	1	3[e]	--	0	0	2[d]	0	0	2[d]	--	0	2	4[d]	--	0	0	2[d]
7	12	70[d,e,f]	100	5	5	90[d,e]	3	5	20[d]	--	3	7	35[d,e]	--	5	28	80[d,e]
2	6	85[d]	--	0	3	8[d]	0	0	7[d]	25	3	6	8[d,e]	--	7	9	12[d,e]

y 1973.

Table 7. Summary of Inspections on NCEL-Treated Piles Installed in 1965[a]

Treatment (Solutions in Xylene)	Retention (lb/ft^3)	No. of Piles	Number of Piles According to Damage Category Attacked in--								
			1976		1978			1982			
			<5%	5-15%	<5%	5-15%	15%	<5%	5-15%	15-20%	>50%
4% copper oxinate	0.87[b]	6	6/6	--	5/6	1/6	--	2/6	4/6	--	--
2% copper oxinate	0.49[b]	6	5/6	1/6	5/6	1/6	--	1/6	4/6	1/6	--
2% copper oxinate 2% tributyltin oxide	0.25[b] 0.25	6	6/6	--	1/6	4/6	1/6	--	--	3/6	3/6
3% copper oxinate 1% Victoria green base	0.69[b] 0.26	5	5/5	--	3/5	2/5	--	1/5	3/5	1/5	--
5% chlordane 2% tributyltin oxide	1.3 0.62	6	6/6	--	6/6	--	--	4/6	2/6	--	--
1.5% copper oxinate 0.5% Victoria green base 50% creosote	0.27[b] 0.09 9.2	6	3/6	3/6	--	5/6	1/6	--	3/6	3/6	--
0.75% copper oxinate 0.25% Victoria green base 75% creosote	0.25[b] 0.08 24.7	6	5/6	1/6	3/6	3/6	--	1/6	4/6	--	1/6

[a]These piles were accidentally pulled in August 1972 and redriven in May 1973.

[b]As metallic copper.

Table 8. Results of Inspections of NCEL- and Industry-Treated P

Treatment	Retention (lb/ft³)	Percent Loss of Cross-Sectio												
		Piling No. 1				Piling No. 2				Piling No. 3				
		1976	1978	1982	1982[a]	1976	1978	1982	1982[a]	1976	1978	1982	1982[a]	1976
Chromated copper arsenate, Type B	0.50	89	100[c,d]	100[e]	--	82	100[c,f]	100[e]	--	2	6	70[c,f]	--	100
Basic zinc sulfate	2.77	0	2	4[c]	--	0	0	2[c]	--	2	2	2[c]	25-50	0
Ammoniacal copper arsenite	0.51	0	1	8[c,f]	25-50	2	2	30[c,f]	75-100	0	4	11[c]	50-75	1
Chromated copper arsenate, Type B Tributyltin oxide	0.50 0.13	0	0	3[c]	10	0	0	7[c]	--	3	5	10[c]	10	0
Basic zinc sulfate Tributyltin oxide	2.66 0.09	0	0	0[c]	0	0	0	0	10	0	0	2[c]	--	0
Ammoniacal copper arsenite Tributyltin oxide	0.51 0.11	0	0	3[f]	--	0	2	3[c]	0	0	1	2[c]	10	0
70-30 creosote-coal tar	31.7	0	0	7[c]	--	7	15	40[c,f]	50-75	0	0	2[c]	10	0
Ammoniacal copper arsenite 70-30 creosote-coal tar	0.51 19.6	0	0	2[g]	--	0	0	2[g]	--	0	1	2	--	0
Copper sulfate Tributyltin oxide	0.06[b] 0.19	6	18	95[c,f]	100	4	7	10[c,f]	--	3	7	40[c]	50-75	3
Copper sulfate Tributyltin oxide	0.03[b] 0.20	3	7	15[c]	--	2	5	40[c,d]	--	0	3	4[c]	--	88

[a]Agi and Associates.

[b]As metallic copper.

[c]*Limnoria*.

[d]*Teredo*.

[e]Pile missing.

[f]*Martesia*.

[g]Few *Limnoria*.

of NCEL- and Industry-Treated Piles Installed in 1966

Percent Loss of Cross-Sectional Area for--																
	Piling No. 3				Piling No. 4				Piling No. 5				Piling No. 6			
982[a]	1976	1978	1982	1982[a]	1976	1978	1982	1982[a]	1976	1978	1982	1982[a]	1976	1977	1982	1982[a]
--	2	6	70[c,f]	--	100	100[c]	100[e]	--	38	100[c,d,f]	100[e]	--	2	3	7[f]	--
--	2	2	2[c]	25-50	0	1	2[c]	10	1	3	4[c]	--	0	2	7[c,f]	--
5-100	0	4	11[c]	50-75	1	2	5[c,f]	--	1	4	7[c,f]	--	1	4	18[c,f]	0-25
--	3	5	10[c]	10	0	1	10[c]	0-25	0	1	4[c,f]	--	1	4	5[c]	--
10	0	0	2[c]	--	0	0	2[c]	--	0	0	1[c]	--	0	1	3[c]	0-25
0	0	1	2[c]	10	0	0	0	--	0	0	2[c]	0	0	3	4[c]	10
0-75	0	0	2[c]	10	0	3	3[c]	0	0	4	10[c]	--	0	1	2[c]	--
--	0	1	2	--	0	0	2	--	0	0	0	--	0	0	2	--
--	3	7	40[c]	50-75	3	3	10[c,d]	10-25	0	2	40[c]	--	3	6	45[c]	100
--	0	3	4[c]	--	88	98[c]	100[e]	100	1	1	12[c]	--	16	90	100[c,f]	100

2

Table 9. Summary of Inspection Results on NCEL- and Industry-Treated Piles Installed in 1966

Treatment	Retention (lb/ft^3)	Number of Piles According to Damage Category Attacked in--											
		1976				1978				1982			
		<5%	5-15%	15-50%	>50%	<5%	5-15%	15-50%	>50%	<5%	5-15%	15-50%	>50%
Chromated copper arsenate, Type B	0.50	2/6	--	1/6	3/6	1/6	1/6	--	4/6	--	1/5	--	5/6
Basic zinc sulfate	2.77	6/6	--	--	--	6/6	--	--	--	4/6	2/6	--	--
Ammoniacal copper arsenite	0.51	6/6	--	--	--	6/6	--	--	--	--	4/6	2/6	--
Chromated copper arsenate, Type B Tributyltin oxide	0.50 0.13	6/6	--	--	--	5/6	1/6	--	--	2/6	4/6	--	--
Basic zinc sulfate Tributyltin oxide	2.66 0.09	6/6	--	--	--	6/6	--	--	--	6/6	--	--	--
Ammoniacal copper arsenite Tributyltin oxide	0.51 0.11	6/6	--	--	--	6/6	--	--	--	6/6	--	--	--
70-30 creosote-coal tar	31.7	5/6	1/6	--	--	5/6	1/6	--	--	3/6	2/6	1/6	--
Ammoniacal copper arsenite 70-30 creosote-coal tar	0.51 19.6	6/6	--	--	--	6/6	--	--	--	6/6	--	--	--
Copper sulfate Tributyltin oxide	0.06[a] 0.19	5/6	1/6	--	--	2/6	3/6	1/6	--	--	2/6	3/6	1/6
Copper sulfate Tributyltin oxide	0.03[a] 0.20	4/6	--	1/6	1/6	2/6	2/6	--	2/6	1/6	1/6	2/6	2/6

[a]As metallic copper.

DISTRIBUTION LIST

ARMY Fal Engr. Letterkenny Army Depot. Chambersburg. PA
AF HQ LEEH (J Stanton) Washington. DC
AFB (AFIT/LDE). Wright Patterson OH; AF Tech Office (Mgt & Ops). Tyndall. FL; CESCH. Wright-Patterson; HQ MAC/DEEE. Scott. Il; HQ Tactical Air Cmd/DEMM (Schmidt) Langley. VA; SAMSO/MNND. Norton AFB CA; Stinfo Library. Offutt NE
AFESC DEB. Tyndall. FL
NATL ACADEMY OF ENG. Alexandria. VA
ARMY ARRADCOM. Dover. NJ; BMDSC-RE (H. McClellan) Huntsville AL; Contracts - Facs Engr Directorate. Fort Ord. CA; DAEN-CWE-M. Washington DC; DAEN-MPE-D Washington DC; DAEN-MPO-U. Washington. DC; DAEN-MPU. Washington DC· ERADCOM Tech Supp Dir. (DELSD-L) Ft. Monmouth. NJ; Tech. Ref. Div.. Fort Huachuca. AZ
ARMY - CERL Library. Champaign IL
ARMY COASTAL ENGR RSCH CEN Fort Belvoir VA; R. Jachowski. Fort Belvoir VA
ARMY COE Philadelphia Dist (LIBRARY) Philadelphia. PA
ARMY CORPS OF ENGINEERS Fac Engr Supp Agency. Ft. Belvoir. VA; MRD-Eng. Div.. Omaha NE; Seattle Dist. Library. Seattle WA
ARMY CRREL R.A. Eaton
ARMY DARCOM Code DRCMM-CS Alexandria VA
ARMY ENG DIV HNDED-CS. Huntsville AL; HNDED-FD. Huntsville. AL
ARMY ENG WATERWAYS EXP STA Library. Vicksburg MS
ARMY ENGR DIST. Library. Portland OR
ARMY ENVIRON. HYGIENE AGCY HSE-EW Water Qual Eng Div Aberdeen Prov Grnd MD
ARMY MATERIALS & MECHANICS RESEARCH CENTER Dr. Lenoe. Watertown MA
ARMY MTMC Trans Engr Agency MTT-CE. Newport News. VA
ARMY-DEPOT SYS COMMAND DRSDS-AI Chambersburg. PA
BUREAU OF RECLAMATION Code 1512 (C. Selander) Denver CO
CINCPAC Fac Engrng Div (J44) Makalapa. HI
CNAVRES Code 13 (Dir. Facilities) New Orleans. LA
CNM Code MAT-08E. Washington. DC; NMAT - 044. Washington DC
CNO Code NOP-964. Washington DC; OP-098. Washington. DC; OP987J. Washington. DC
COMCBPAC Operations Off. Makalapa HI
COMFLEACT. OKINAWA PWD - Engr Div. Sasebo. Japan; PWO. Kadena. Okinawa; PWO. Sasebo. Japan
COMNAVAIRLANT NUC Wpns Sec Offr Norfolk. VA
COMOCEANSYSLANT PW-FAC MGMNT Off Norfolk. VA
COMOCEANSYSPAC SCE. Pearl Harbor HI
DEFFUELSUPPCEN DFSC-OWE (Term Engrng) Alexandria. VA; DFSC-OWE. Alexandria VA
DOE Div Ocean Energy Sys Cons/Solar Energy Wash DC
DTIC Defense Technical Info Ctr/Alexandria. VA
DTNSRDC Anna Lab. Code 4121 (R A Rivers) Annapolis. MD
DTNSRDC Code 172 (M. Krenzke). Bethesda MD
DTNSRDC Code 284 (A. Rufolo). Annapolis MD
DTNSRDC Code 4111 (R. Gierich). Bethesda MD; Code 42. Bethesda MD
FLTCOMBATTRACENLANT PWO. Virginia Bch VA
FMFLANT CEC Offr. Norfolk VA
GIDEP OIC. Corona. CA
GSA Assist Comm Des & Cnst (FAIA) D R Dibner Washington. DC
KWAJALEIN MISRAN BMDSC-RKL-C
LIBRARY OF CONGRESS Washington. DC (Sciences & Tech Div)
MARINE CORPS BASE Code 406. Camp Lejeune. NC; M & R Division. Camp Lejeune NC; Maint Off Camp Pendleton. CA; PWD - Maint. Control Div. Camp Butler. Kawasaki. Japan; PWO Camp Lejeune NC; PWO. Camp Pendleton CA; PWO. Camp S. D. Butler. Kawasaki Japan
MARINE CORPS HQS Code LFF-2. Washington DC
MCAS Facil. Engr. Div. Cherry Point NC; CO. Kaneohe Bay HI; Code S4. Quantico VA; Facs Maint Dept - Operations Div. Cherry Point; PWD - Utilities Div. Iwakuni. Japan; PWD. Dir. Maint. Control Div.. Iwakuni Japan; PWO. Iwakuni. Japan; PWO. Yuma AZ
MCDEC M&L Div Quantico VA
MCRD SCE. San Diego CA
NAF PWD - Engr Div. Atsugi. Japan; PWO. Atsugi Japan
NALF OINC. San Diego. CA
NARF Code 100. Cherry Point. NC; Code 640. Pensacola FL; Equipment Engineering Division (Code 61000). Pensacola. FL; SCE Norfolk. VA

NAS CO, Guantanamo Bay Cuba; Code 114, Alameda CA; Code 183 (Fac. Plan BR MGR); Code 18700, Brunswick ME; Code 18U (ENS P.J. Hickey), Corpus Christi TX; Code 6234 (G. Trask), Point Mugu CA; Code 70, Atlanta, Marietta GA; Code 8E, Patuxent Riv., MD; Dir of Engrng, PWD, Corpus Christi, TX; Dir. Maint. Control Div., Key West FL; Dir. Util. Div., Bermuda; Lakehurst, NJ; Lead. Chief. Petty Offr. PW/Self Help Div. Beeville TX; OIC, CBU 417, Oak Harbor WA; PW (J. Maguire), Corpus Christi TX; PWD - Engr Div Dir, Millington, TN; PWD - Engr Div, Gtmo, Cuba; PWD - Engr Div, Oak Harbor, WA; PWD Maint. Cont. Dir., Fallon NV; PWD Maint. Div., New Orleans, Belle Chasse LA; PWD, Code 1821H (Pfankuch) Miramar, SD CA; PWD, Maintenance Control Dir., Bermuda; PWD, Willow Grove PA; PWO Belle Chasse, LA; PWO Chase Field Beeville, TX; PWO Key West FL; PWO Lakehurst, NJ; PWO Sigonella Sicily; PWO, Dallas TX; PWO, Glenview IL; PWO, Kingsville TX; PWO, Millington TN; PWO, Miramar, San Diego CA; PWO., Moffett Field CA; SCE Norfolk, VA; SCE, Barbers Point HI; SCE, Cubi Point, R.P; Security Offr, Alameda CA

NASDC-WDC T. Fry, Manassas VA

NATL BUREAU OF STANDARDS B-348 BR (Dr. Campbell), Washington DC

NATL RESEARCH COUNCIL Naval Studies Board, Washington DC

NAVACT PWO, London UK

NAVACTDET PWO, Holy Lock UK

NAVAEROSPREGMEDCEN SCE, Pensacola FL

NAVAIRDEVCEN Code 813, Warminster PA

NAVAIRPROPTESTCEN CO, Trenton, NJ

NAVAIRTESTCEN PATUXENT RIVER PWD (F. McGrath), Patuxent Riv.,MD

NAVAVIONICFAC PW Div Indianapolis, IN; PWD Deputy Dir. D/701, Indianapolis, IN

NAVAVNWPNSFAC Wpns Offr, St. Mawgan, England

NAVCHAPGRU Engineering Officer, Code 60 Williamsburg, VA

NAVCOASTSYSCEN Code 423 Panama City, FL; Code 715 (J Quirk) Panama City, FL; Code 715 (J. Mittleman) Panama City, FL; Library Panama City, FL; PWO Panama City, FL

NAVCOMMAREAMSTRSTA Code W-60, Elec Engr, Wahiawa, HI; PWO, Norfolk VA; SCE Unit 1 Naples Italy; SCE, Wahiawa HI

NAVCOMMSTA Code 401 Nea Makri, Greece; PWD - Maint Control Div, Diego Garcia Is.; PWO, Exmouth, Australia; SCE, Balboa, CZ

NAVCONSTRACEN Curriculum/Instr. Stds Offr, Gulfport MS

NAVEDTRAPRODEVCEN Technical Library, Pensacola, FL

NAVEDUTRACEN Engr Dept (Code 42) Newport, RI

NAVENVIRHLTHCEN CO, NAVSTA Norfolk, VA

NAVEODTECHCEN Code 605, Indian Head MD

NAVFAC PWO, Centerville Bch, Ferndale CA; PWO, Point Sur, Big Sur CA

NAVFACENGCOM Alexandria, VA; Code 03 Alexandria, VA; Code 03T (Essoglou) Alexandria, VA; Code 043 Alexandria, VA; Code 0453 (D. Potter) Alexandria, VA; Code 0453C, Alexandria, VA; Code 0454B Alexandria, Va; Code 046; Code 0461D (V M Spaulding) Alexandria, VA; Code 04A1 Alexandria, VA; Code 04B3 Alexandria, VA; Code 051A Alexandria, VA; Code 09M54, Tech Lib, Alexandria, VA; Code 100 Alexandria, VA; Code 1002B (J. Leimanis) Alexandria, VA; Code 1113, Alexandria, VA; Code 461D, Alexandria, VA

NAVFACENGCOM - CHES DIV. Code 101 Wash, DC; Code 403 Washington DC; Code 405 Wash, DC; Code 407 (D Scheesele) Washington, DC; Code FPO-1C Washington DC; Contracts, ROICC, Annapolis MD; FPO-1 Washington, DC; FPO-1EA5 Washington DC; Library, Washington, D.C.

NAVFACENGCOM - LANT DIV. Code 403, Norfolk, VA; Eur. BR Deputy Dir, Naples Italy; Library, Norfolk, VA; RDT&ELO 102A, Norfolk, VA

NAVFACENGCOM - NORTH DIV. CO; Code 04 Philadelphia, PA; Code 09P Philadelphia PA; Code 111 Philadelphia, PA; Code 405 Philadelphia, PA; Code 04AL, Philadelphia PA; ROICC, Contracts, Crane IN

NAVFACENGCOM - PAC DIV. (Kyi) Code 101, Pearl Harbor, HI; CODE 09P PEARL HARBOR HI; Code 2011 Pearl Harbor, HI; Code 402, RDT&E, Pearl Harbor HI; Commander, Pearl Harbor, HI; Library, Pearl Harbor, HI

NAVFACENGCOM - SOUTH DIV. Code 405 Charleston, SC; Code 411 Soil Mech & Paving BR Charleston, SC; Code 90, RDT&ELO, Charleston SC; Library, Charleston, SC

NAVFACENGCOM - WEST DIV. 102; AROICC, Contracts, Twentynine Palms CA; Code 04B San Bruno, CA; Library, San Bruno, CA; O9P/20 San Bruno, CA; RDT&ELO Code 2011 San Bruno, CA

NAVFACENGCOM CONTRACTS AROICC, NAVSTA Brooklyn, NY; AROICC, Quantico, VA; Colts Neck, NJ; Contracts, AROICC, Lemoore CA; Dir, Eng. Div., Exmouth, Australia; Eng Div dir, Southwest Pac, Manila, PI; NAS, Jacksonville, FL; OICC, Southwest Pac, Manila, PI; OICC-ROICC, NAS Oceana, Virginia Beach, VA; OICC/ROICC, Balboa Panama Canal; OICC/ROICC, Norfolk, VA; ROICC AF Guam; ROICC Code 495 Portsmouth VA; ROICC Key West FL; ROICC MCAS El Toro; ROICC Rota Spain; ROICC, Diego Garcia Island; ROICC, Keflavik, Iceland; ROICC, NAS, Corpus Chrisii, TX; ROICC, Pacific, San Bruno CA; ROICC, Point Mugu, CA; ROICC, Yap; ROICC-OICC-SPA, Norfolk, VA

NAVMAG PWD - Engr Div, Guam; SCE, Guam; SCE, Subic Bay, R.P.

NAVOCEANO Code 3432 (J. DePalma), Bay St. Louis MS; Library Bay St. Louis, MS

NAVOCEANSYSCEN Code 09 (Talkington). San Diego. CA; Code 4473 Bayside Library. San Diego. CA; Code 4473B (Tech Lib) San Diego. CA; Code 5221 (R.Jones) San Diego Ca; Code 6700. San Diego. CA
NAVORDMISTESTFAC PWD - Engr Dir. White Sands. NM
NAVORDSTA PWO. Louisville KY
NAVPETOFF Code 30. Alexandria VA
NAVPHIBASE CO. ACB 2 Norfolk. VA; Code S3T. Norfolk VA; Harbor Clearance Unit Two. Little Creek. VA; SCE Coronado. SD.CA
NAVRADRECFAC PWO. Kami Seya Japan
NAVREGMEDCEN Code 3041. Memphis. Millington TN; PWD - Engr Div. Camp Lejeune. NC; PWO Portsmouth. VA; PWO. Camp Lejeune. NC
NAVREGMEDCEN PWO. Okinawa. Japan
NAVREGMEDCEN SCE; SCE San Diego. CA; SCE. Camp Pendleton CA; SCE. Guam; SCE. Newport. RI; SCE. Oakland CA
NAVREGMEDCEN SCE. Yokosuka. Japan
NAVSCOLCECOFF C35 Port Hueneme. CA; CO. Code C44A Port Hueneme. CA
NAVSCSOL PWO. Athens GA
NAVSEASYSCOM Code 05E1. Wash. DC; SEA05E1. Washington. D.C.
NAVSECGRUACT Facil. Off.. Galeta Is. Panama Canal; PWO. Adak AK; PWO. Edzell Scotland; PWO. Puerto Rico; PWO. Torri Sta. Okinawa
NAVSECSTA PWD - Engr Div. Wash.. DC
NAVSHIPREPFAC Library. Guam; SCE Subic Bay
NAVSHIPYD Bremerton. WA (Carr Inlet Acoustic Range); Code 134. Pearl Harbor. HI; Code 202.4. Long Beach CA; Code 202.5 (Library) Puget Sound. Bremerton WA; Code 380. Portsmouth. VA; Code 382.3. Pearl Harbor. HI; Code 400. Puget Sound; Code 410. Mare Is.. Vallejo CA; Code 440 Portsmouth NH; Code 440. Norfolk; Code 440. Puget Sound. Bremerton WA; Commander. Philadelphia. PA; L.D. Vivian; Library. Portsmouth NH; PWD (Code 420) Dir Portsmouth. VA; PWD (Code 450-HD) Portsmouth. VA; PWD (Code 457-HD) Shop 07. Portsmouth. VA; PWD (Code 460) Portsmouth. VA; PWO. Bremerton. WA; PWO. Mare Is.; PWO. Puget Sound; SCE. Pearl Harbor HI; Tech Library. Vallejo. CA
NAVSTA CO Roosevelt Roads P.R. Puerto Rico; CO. Brooklyn NY; Code 4. 12 Marine Corps Dist. Treasure Is.. San Francisco CA; Dir Engr Div. PWD. Mayport FL; Dir Mech Engr 37WC93 Norfolk. VA; Engr. Dir.. Rota Spain; Long Beach. CA; Maint. Cont. Div.. Guantanamo Bay Cuba; PWD (LTJG.P.M. Motolenich). Puerto Rico; PWD - Engr Dept. Adak. AK; PWD - Engr Div. Midway Is.; PWO. Guantanamo Bay Cuba; PWO. Keflavik Iceland; PWO. Mayport FL; SCE. Guam; SCE. Pearl Harbor HI; SCE. San Diego CA; SCE. Subic Bay. R.P.; Utilities Engr Off. Rota Spain
NAVSUBASE Code 23 (Slowey) Bremerton. WA; SCE. Pearl Harbor HI
NAVSUPPACT PWO Naples Italy
NAVSUPPFAC PWD - Maint. Control Div. Thurmont. MD
NAVSURFWPNCEN PWO. White Oak. Silver Spring. MD
NAVTECHTRACEN SCE. Pensacola FL
NAVWPNCEN Code 2636 China Lake; Code 3803 China Lake. CA; PWO (Code 266) China Lake. CA; ROICC (Code 702). China Lake CA
NAVWPNSTA (Clebak) Colts Neck. NJ; Code 092. Colts Neck NJ; Code 092. Concord CA; Maint. Control Dir.. Yorktown VA
NAVWPNSTA PW Office Yorktown. VA
NAVWPNSTA PWD - Maint. Control Div.. Concord. CA; PWD - Supr Gen Engr. Seal Beach. CA; PWO. Charleston. SC; PWO. Seal Beach CA
NAVWPNSUPPCEN Code 09 Crane IN
NCBU 405 OIC. San Diego. CA
NCTC Const. Elec. School. Port Hueneme. CA
NCBC Code 10 Davisville. RI; Code 15. Port Hueneme CA; Code 155. Port Hueneme CA; Code 156. Port Hueneme. CA; Code 400. Gulfport MS; Code 430 (PW Engrng) Gulfport. MS; PWO (Code 80) Port Hueneme. CA; PWO. Davisville RI; PWO. Gulfport. MS
NCBU 411 OIC. Norfolk VA
NCR 20. Code R70; 20. Commander
NMCB 74. CO; FIVE. Operations Dept; Forty. CO; THREE. Operations Off.
NOAA Library Rockville. MD
NORDA Code 440 (Ocean Rsch Off) Bay St. Louis MS
NRL Code 5800 Washington. DC; Code 8441 (R.A. Skop). Washington DC
NROTC J.W. Stephenson. UC. Berkeley. CA
NSC Code 54.1 Norfolk. VA
NSD SCE. Subic Bay. R.P.
NTC OICC. CBU-401. Great Lakes IL
NUSC Code EA123 (R.S. Munn). New London CT; Code TA131 (G. De la Cruz). New London CT
OFFICE SECRETARY OF DEFENSE OASD (MRA&L) Dir. of Energy. Pentagon. Washington. DC
ONR Central Regional Office. Boston. MA; Code 485 (Silva) Arlington. VA; Code 700F Arlington VA
PACMISRANFAC HI Area Bkg Sands. PWO Kekaha. Kauai. HI

PHIBCB 1 P&E, San Diego, CA
PWC ACE Office Norfolk, VA; CO Norfolk, VA; CO, (Code 10), Oakland, CA; CO, Great Lakes IL; CO, Pearl Harbor HI; Code 10, Great Lakes, IL; Code 105 Oakland, CA; Code 110, Oakland, CA; Code 120, Oakland CA; Code 128, Guam; Code 154 (Library), Great Lakes, IL; Code 200, Great Lakes IL; Code 200, Guam; Code 400, Great Lakes, IL; Code 400, Oakland, CA; Code 400, Pearl Harbor, HI; Code 400, San Diego, CA; Code 420, Great Lakes, IL; Code 420, Oakland, CA; Code 424, Norfolk, VA; Code 500 Norfolk, VA; Code 505A Oakland, CA; Code 600, Great Lakes, IL; Code 610, San Diego Ca; Code 700, Great Lakes, IL; Code 700, San Diego, CA; Library, Code 120C, San Diego, CA; Library, Pensacola, FL; Library, Guam; Library, Norfolk, VA; Library, Oakland, CA; Library, Pearl Harbor, HI; Library, Subic Bay, R.P.; Library, Yokosuka JA; Utilities Officer, Guam
SPCC PWO (Code 120) Mechanicsburg PA
SUPANX PWO, Williamsburg VA
TVA Smelser, Knoxville, Tenn.; Solar Group, Arnold, Knoxville, TN
UCT ONE OIC, Norfolk, VA
UCT TWO OIC, Port Hueneme CA
U.S. MERCHANT MARINE ACADEMY Kings Point, NY (Reprint Custodian)
US GEOLOGICAL SURVEY Off. Marine Geology, Piteleki, Reston VA
USAF SCHOOL OF AEROSPACE MEDICINE Hyperbaric Medicine Div, Brooks AFB, TX
USCG (Smith), Washington, DC; G-EOE-4 (T Dowd), Washington, DC
USDA Forest Products Lab, Madison WI; Forest Products Lab. (R. DeGroot), Madison WI; Forest Service Reg 3 (R. Brown) Albuquerque, NM; Forest Service, Bowers, Atlanta, GA
USNA ENGRNG Div, PWD, Annapolis MD; PWO Annapolis MD; USNA/SYS ENG DEPT ANNAPOLIS MD
USS FULTON WPNS Rep. Offr (W-3) New York, NY
WATER & POWER RESOURCES SERVICE (Smoak) Denver, CO
AMERICAN CONCRETE INSTITUTE Detroit MI (Library)
BERKELEY PW Engr Div, Harrison, Berkeley, CA
CALIF. DEPT OF NAVIGATION & OCEAN DEV. Sacramento, CA (G. Armstrong)
CALIF. MARITIME ACADEMY Vallejo, CA (Library)
CLARKSON COLL OF TECH G. Batson, Potsdam NY
CORNELL UNIVERSITY Ithaca NY (Serials Dept, Engr Lib.); Ithaca, NY (Civil & Environ. Engr)
DAMES & MOORE LIBRARY LOS ANGELES, CA
DUKE UNIV MEDICAL CENTER B. Muga, Durham NC
UNIVERSITY OF DELAWARE (Dr. S. Dexter) Lewes, DE
FLORIDA ATLANTIC UNIVERSITY Boca Raton FL (W. Hartt); Boca Raton, FL (McAllister)
HARVARD UNIV. Dept. of Architecture, Dr. Kim, Cambridge, MA
INSTITUTE OF MARINE SCIENCES Morehead City NC (Director)
WOODS HOLE OCEANOGRAPHIC INST. Woods Hole MA (Winget)
LEHIGH UNIVERSITY BETHLEHEM, PA (MARINE GEOTECHNICAL LAB., RICHARDS); Bethlehem PA (Linderman Lib. No.30, Flecksteiner)
MAINE MARITIME ACADEMY CASTINE, ME (LIBRARY)
MICHIGAN TECHNOLOGICAL UNIVERSITY Houghton, MI (Haas)
MIT Cambridge MA; Cambridge MA (Rm 10-500, Tech. Reports, Engr. Lib.)
NATL ACADEMY OF ENG. ALEXANDRIA, VA (SEARLE, JR.)
NATURAL ENERGY LAB Library, Honolulu, HI
NEW MEXICO SOLAR ENERGY INST. Dr. Zwibel Las Cruces NM
NY CITY COMMUNITY COLLEGE BROOKLYN, NY (LIBRARY)
OREGON STATE UNIVERSITY (CE Dept Grace) Corvallis, OR; CORVALLIS, OR (CE DEPT, HICKS); Corvalis OR (School of Oceanography)
PENNSYLVANIA STATE UNIVERSITY STATE COLLEGE, PA (SNYDER)
PURDUE UNIVERSITY Lafayette IN (Leonards); Lafayette, IN (Altschaeffl); Lafayette, IN (CE Engr. Lib)
SAN DIEGO STATE UNIV. I. Noorany San Diego, CA
SCRIPPS INSTITUTE OF OCEANOGRAPHY LA JOLLA, CA (ADAMS); San Diego, CA (Marina Phy. Lab. Spiess)
SEATTLE U Prof Schwaegler Seattle WA
SOUTHWEST RSCH INST R. DeHart San Antonio TX
STATE UNIV. OF NEW YORK Buffalo, NY
TEXAS A&M UNIVERSITY College Station TX (CE Dept. Herbich); W.B. Ledbetter College Station, TX
UNIVERSITY OF ALASKA Marine Science Inst. College, AK
UNIVERSITY OF CALIFORNIA BERKELEY, CA (CE DEPT, GERWICK); Berkeley CA (E. Pearson); DAVIS, CA (CE DEPT, TAYLOR)
UNIVERSITY OF DELAWARE Newark, DE (Dept of Civil Engineering, Chesson)
UNIVERSITY OF HAWAII HONOLULU, HI (SCIENCE AND TECH. DIV.)
UNIVERSITY OF ILLINOIS (Hall) Urbana, IL; Metz Ref Rm, Urbana IL; URBANA, IL (DAVISSON); URBANA, IL (LIBRARY); Urbana IL (CE Dept, W. Gamble)
UNIVERSITY OF MASSACHUSETTS (Heronemus), ME Dept, Amherst, MA
UNIVERSITY OF MICHIGAN Ann Arbor MI (Richart)

UNIVERSITY OF NEBRASKA-LINCOLN Lincoln, NE (Ross Ice Shelf Proj.)
UNIVERSITY OF PENNSYLVANIA PHILADELPHIA, PA (SCHOOL OF ENGR & APPLIED SCIENCE, ROLL)
UNIVERSITY OF TEXAS Inst. Marine Sci (Library), Port Arkansas TX
UNIVERSITY OF TEXAS AT AUSTIN AUSTIN, TX (THOMPSON); Austin, TX (Breen)
UNIVERSITY OF WASHINGTON Dept of Civil Engr (Dr. Mattock), Seattle WA; SEATTLE, WA (OCEAN ENG RSCH LAB, GRAY); Seattle WA (E. Linger)
UNIVERSITY OF WISCONSIN Milwaukee WI (Ctr of Great Lakes Studies)
VENTURA COUNTY PWA (Brownie) Ventura, CA
WESTERN ARCHEOLOGICAL CENTER Library, Tucson AZ
ALFRED A. YEE & ASSOC. Librarian, Honolulu, HI
AMETEK Offshore Res. & Engr Div
ARVID GRANT OLYMPIA, WA
ATLANTIC RICHFIELD CO. DALLAS, TX (SMITH)
BECHTEL CORP. SAN FRANCISCO, CA (PHELPS)
BETHLEHEM STEEL CO. Dismuke, Bethelehem, PA
BROWN & ROOT Houston TX (D. Ward)
CHEMED CORP Lake Zurich IL (Dearborn Chem. Div.Lib.)
COLUMBIA GULF TRANSMISSION CO. HOUSTON, TX (ENG. LIB.)
CONTINENTAL OIL CO O. Maxson, Ponca City, OK
DILLINGHAM PRECAST F. McHale, Honolulu HI
DRAVO CORP Pittsburgh PA (Wright)
EVALUATION ASSOC. INC KING OF PRUSSIA, PA (FEDELE)
EXXON PRODUCTION RESEARCH CO Houston, TX (Chao)
GENERAL DYNAMICS Elec. Boat Div., Environ. Engr (H. Wallman), Groton CT
GEOTECHNICAL ENGINEERS INC. Winchester, MA (Paulding)
GLIDDEN CO. STRONGSVILLE, OH (RSCH LIB)
GOULD INC. Tech Lib, Ches Instru Div Glen Burnie MD
HALEY & ALDRICH, INC. Cambridge MA (Aldrich, Jr.)
NUSC Library, Newport, RI
KENNETH TATOR ASSOC CORAOPOLIS, PA (LIBRARY)
LIN OFFSHORE ENGRG P. Chow, San Francisco CA
LOCKHEED MISSILES & SPACE CO. INC. Dept 57-22 (Rynewicz) Sunnyvale, CA
MARATHON OIL CO Houston TX
MARINE CONCRETE STRUCTURES INC. MEFAIRIE, LA (INGRAHAM)
MCDONNEL AIRCRAFT CO. (Fayman) Engrng Dept., St. Louis, MO
MOBIL PIPE LINE CO. DALLAS, TX MGR OF ENGR (NOACK)
MOFFATT & NICHOL ENGINEERS (R. Palmer) Long Beach, CA
MUESER, RUTLEDGE, WENTWORTH AND JOHNSTON New York (Richards)
NEWPORT NEWS SHIPBLDG & DRYDOCK CO. Newport News VA (Tech. Lib.)
PACIFIC MARINE TECHNOLOGY (M. Wagner) Duvall, WA
PORTLAND CEMENT ASSOC. SKOKIE, IL (CORLEY; SKOKIE, IL (KLIEGER); Skokie IL (Rsch & Dev Lab, Lib.)
RAYMOND INTERNATIONAL INC. E Colle Soil Tech Dept, Pennsauken, NJ; J. Welsh Soiltech Dept, Pennsauken, NJ
SCHUPACK ASSOC SO. NORWALK, CT (SCHUPACK)
SEAFOOD LABORATORY MOREHEAD CITY, NC (LIBRARY)
SEATECH CORP. MIAMI, FL (PERONI)
SHELL OIL CO. HOUSTON, TX (MARSHALL); Houston TX (R. de Castongrene)
TEXTRON INC BUFFALO, NY (RESEARCH CENTER LIB.)
TIDEWATER CONSTR. CO Norfolk VA (Fowler)
TILGHMAN STREET GAS PLANT (Sreas), Chester, PA
UNION CARBIDE CORP. R.J. Martell Boton, MA
WESTINGHOUSE ELECTRIC CORP. Annapolis MD (Oceanic Div Lib, Bryan); Library, Pittsburgh PA
WEYERHAEUSER CO. (Fortman) Tacoma, WA
WISS, JANNEY, ELSTNER, & ASSOC Northbrook, IL (D.W. Pfeifer)
WM CLAPP LABS - BATTELLE DUXBURY, MA (LIBRARY)
WOODWARD-CLYDE CONSULTANTS (Dr. M. Akky), San Francisco, CA; (Dr. R. Dominguez), Houston, TX; PLYMOUTH MEETING PA (CROSS, III)
ANTON TEDESKO Bronxville NY
BRAHTZ La Jolla, CA
BULLOCK La Canada
DOBROWOLSKI, J.A. Altadena, CA
ERVIN, DOUG Belmont, CA
GERWICK, BEN C. JR San Francisco, CA

LAYTON Redmond, WA
PAULI Silver Spring, MD
R.F. BESIER Old Saybrook CT
BROWN & CALDWELL Saunders, E.M./Oakland, CA
SMITH Gulfport, MS
T.W. MERMEL Washington DC

END

DATE FILMED

10 83

DT